were deposited, lived a most remarkable group of herbivores, all of which were, roughly speaking, less specialised than any now on the face of the earth. The Oreodon, a ruminant about the size of a large domestic sheep, was there in considerable abundance, and must have lived in herds, after the manner of the bison in the neighbouring region. It was an animal of a strangely composite kind; to the molar teeth of a ruminant it added the ulna and radius of a hog; it possessed a cranial and temporal region like that of the camel, and larmiers beneath the orbit as in the Cervidæ and the musk-sheep. Its canines were trilateral and worn like those of a pig, and its dental armature was complete all round. Three closely-allied forms, the Merychochœrus, Leptauchenia, and Agriochœrus, are associated with Oreodon, and form a group which, judged by existing forms of life, stands half-way between the pigs and the ruminants. It is an admirable instance of one of Prof. Huxley's "intercalary types." The camel or lama was represented by two allied forms, the Pœbrothere and Protomeryx, and the musk-deer by the Leptomeryx. The Artiodactyle division was present in very strong force. The Elotherium is allied to the hog, peccary, and hippopotamus. In a full complement of teeth it possessed a canine almost carnivorous in character. It was probably less omnivorous than any of the class now living. The Perchœrus, Leptochœrus, and Nanohyus, form members of the same class, together with the Hyopotamus and the Titanothere, which was possessed of a well-developed and separate ulna and radius. The remains of rhinoceros indicate one, and perhaps two forms, during the American Miocenes. The lowness of the crowns of their teeth, the large development of the incisors, and the absence of any trace of horn-basis on the skulls which have been preserved, imply that they belong to the hornless section Aceratherium, of Dr. Kaup, rather than to the true rhinoceros. Dr. Leidy has very rightly separated Hyracodon from the true rhinoceros, because it has the full complement of teeth in both jaws. The Anchithere represented the horse in this fauna; the Palœolagus the hare; and there were also squirrels, beavers, mice, and hedgehogs present.

There was also a corresponding development of the Carnivora. Two species of Amphicyon performed the function of the living foxes and wolves; the Hyænodon that of the hyæna; while the great Machairodus, and the allied form Dinictis, represented the lions, tigers, and other larger felines.

If this fauna be compared with that of the European Miocenes, several important differences and resemblances may be remarked. The whole group of antelopes, found in such numbers in the classic plains of Pikermi by M. Gaudré, and in central France, are absent. The giraffe also, and the family of the Cervidæ, and the horse, elephant, Mastodon and Hipparion of Europe, are equally absent. Other genera are common to both Europe and America. The *Elotherium Moretoni* of the Mauvaises Terres can scarcely be distinguished from the *E. Aymardi* of the Gironde. The *Anchitherium Bairdi* cannot be distinguished with certainty from the *A. Aurelianense* of France. The rhinoceros and Aceratherium of Eppelsheim and Pikermi find their analogues in the so-called *Rhinoceros occidentalis* and *R. meridianus* of America, while the Hyracodon recalls forcibly to mind the small rhinoceros from Sansan (*Aceratherium Sansanense*). The Lophiodon is also an American form. Of the Carnivores, the *Amphicyon vetus* is the equivalent of the *A. major* of De Blainville from Sansan, while the Hyænodon and the sabre-toothed Machairodus were the scourge of the Miocene herbivores in America as in Europe. The family of the Oreodontidæ, on the other hand, seem peculiar to America, as also the Titanothere and the small carnivore the Dinictis.

This distribution of life throws considerable light on the physical geography of the northern hemisphere during the Miocene period. The absence of the South American forms which were living at the time, the apes, the rodents, and the edentata, implies the presence of a barrier between North and South America, which prevented migration from the one to the other; and this barrier was most probably, as Prof. Huxley remarked in his last address to the Geological Society, an open sea. The forms of life common to Europe and North America imply a continuity of land between those now widely dissociated areas. Mr. Murray believes in the existence of a Miocene Atlantis, which has left the Sarghasso sea as a palpable monument of its existence in the mid-ocean. I should, however, be rather inclined to look for the continuity of land in the direction of Siberia, Behring's Straits, and, it may be, Greenland; and when the recent wonderful discoveries of temperate and sub-tropical vegetation in the now Arctic regions is taken into account, it appears to me extremely probable that the animals migrated from one area to the other by that pathway. But whether this be accepted or not, Prof. Heer has shown that during the Miocene times there was a vast extent of land, and a temperate climate in the now extremely high northern latitudes, which would imply conditions of life favourable for the migration of the Miocene animals. It is impossible to find out with any certainty the direction which the Miocene migration took, whether from America towards Europe and Asia, or *vice versa*. There is, however, one very significant fact to be observed, that the American Miocene fauna is less specialised than the European, or, in other words, that it is of an older type. It contains no true hyænas, nor deer, nor antelopes, nor any of the living genera which first appeared in the Miocenes of Europe. Possibly in point of time, or rather in homotaxy, it was older and more closely allied to the Eocene. The explanation which strongly suggests itself to my mind is that the migration set in from the old world, and that the above-named living genera sprang into being here, and are not found in the American Miocenes, because they had not time to reach that area. Thus the absence of certain extinct genera, such as mastodon and hipparion, may be accounted for. That eventually they found their way thither will be seen in the succeeding part of this essay relating to the Pliocene.

W. BOYD DAWKINS

NAUMANN ON THERMO-CHEMISTRY

Grundriss der Thermochemie. By S. Alex. Naumann. 8vo. pp. viii. and 150; price 3*s*. (Brunswick, 1869. London: Williams and Norgate.)

IT is not altogether without reason that modern chemists are accustomed to point, as a proof of their activity, to the amount of materials they have succeeded in accumulating. The fact, indeed, is sufficiently familiar to most students.

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If any one will examine a popular chemical manual, he will find its pages occupied almost wholly with experimental results, connected by an imperfect and partial classification. Should he feel envious to know what laws have been acquired by the science, or how far it at present possesses a deductive form, the whole of the information he seeks is generally proffered in a few paragraphs. Nor can it be denied that, as a rule, the manuals have given a fair representation of the kind of chemistry that we are compelled to use for the purposes of teaching. But not only has this state of things been repeatedly predicted; the result has also been discerned. The most distinguished chemists have from time to time seen the fundamental identity that exists between their own science and that of physics, and have recommended the conjoint study of these subjects as likely to prove of the greatest advantage to each, until the apparent and illusive difference between them shall have vanished, and their separate efforts be blended in a single enterprise. In recent times, the special character formerly assigned to chemistry is advocated only by the few who are content with the prevailing style of research. Every one will, therefore appreciate the eager interest that has always been shown in any attempt to construct a firm and logical union between chemistry and physics. Such an union is now being accomplished by the science of Thermo-chemistry.

If we look back to the beginning of this century, we shall see how little reason we had to expect that the desired result would be brought about in such a manner. At that time, there were but few who did not regard heat as, in some way or other, a kind of matter, and not many who deemed its study of much importance. Lavoisier, it is true, touched the obscure topic with his restless fingers; but while we cannot withhold our respect from the inventor of the calorimeter, few will excuse the great opponent of phlogiston for his theory of caloric. Thénard, on the other hand, was the first to show, in his classification of the metals, the great importance to chemistry of the study of temperature. His principles and the fruit of his teaching can easily be traced in modern chemistry. But it was not in the study of pure thermotics that thermo-chemistry took its rise. That science could not furnish, what the weakness of the mind invariably demands, a conception on which to proceed. Heat might be a mode of motion. But motion of *what?* The passage in which Rumford announced his discovery is sublime in its simplicity and unsullied by any materialistic taint. The popular prejudice stripped that magnificent idea of its regal investiture, and clothed it in the garments of a corpuscular theory. Dalton's atomic doctrine, at first received with coldness, has long been almost universally accepted among chemists; but it is only, perhaps, within the last decennium (for Mayer and Joule must be omitted) that a few prominent physicists, among whom Naumann himself is to be enumerated, have given in their adhesion to Dalton's fundamental views, and constructed for themselves a new basis on which to work. Thus, then, has arisen the science of thermo-chemistry; and it is not, consequently, very surprising that it should teach us that heat is a kind of undulatory movement (*Bewegungsform*) of molecules or atoms. On the whole, we are inclined to regard the atomic constituent of the infant science as "accidental" (to borrow a term from mineralogy); in anything equal to a calculus, it will prove to be an intolerable hindrance to perspicuity, infecting the purely inductive part with a host of extraneous entanglements.

Professor Naumann is far too acute and experienced a reasoner not to perceive that it is precisely at this point that objections are most likely to be made. Accordingly he is careful to fortify his position by a well-digested chapter on the atomic theory, in which the usual arguments are advanced with much more than the usual thought and distinctness. It may aid the reader to form a judgment of how far his author has succeeded, if we notice one or two points in the discussion. Almost at the outset, we are warned that demands on the accuracy of a scientific theorist must not be severe or stern. "The essential value of a theory does not consist so much in its fundamental hypotheses, but in the connecting of known facts and enabling us to discover new relations." Further on there is sufficient confusion in the terms employed to mislead one into supposing that an element enters into combination with unaltered properties; whereas, of course, it must always gain or lose by that process. The existence of bodies having the same per-centage composition, but different reactions, is adduced to prove that the matter in them must be divided into discrete parts in each case. Does it not rather prove that matter has nothing whatever to do with chemical properties? Again, the passage beginning "If we now suppose the process of mechanical division to be carried on continuously, a limit must at length appear," &c., is as clear a case of *petitio principii* as we remember to have met with.

The work of Professor Naumann is intended as a sort of summary, in a form specially designed for the student, of what the science of thermo-chemistry has been able to achieve. The accomplished author, who has taken a most important practical share in the results he describes, has spared no pains to perfect his labour with such an end in view. We need hardly say that an effort, in itself so desirable and meritorious, is in its result both opportune and intelligible. We may as well, perhaps, point out that the chapters on Dissociation and kindred subjects have received, as was natural, the greatest amount of development.

The progress of biology has repeatedly been opposed by an obstacle which, under the name of "mind," it has scarcely known how to treat, but with respect to which it is just beginning to find its true position. In like manner, physical science, and chemistry particularly, has had to encounter a phenomenon which, under the name of "matter," has continually impressed upon it the heaviest and most severe of theoretical burdens. It will be strange, indeed, if biology should steal a march on physics.

E. J. MILLS

OUR BOOK SHELF

The Interior of the Earth. By H. P. Malet, F.L.C.S. 8vo, pp. 175. (London: Hodder and Stoughton, 1870.)

THIS is a very good example of a book which ought never to have been written. The author tells us in the introduction that, in approaching the most complicated problem of the condition of the interior of the earth, he has "culled from contemporary literature such extracts as fit" his

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